PHASE ANALYSIS OF CARDIAC ACTIVITY OF Macacus rhesus AND Papio hamadryas

G. S. Belkaniya

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A polycardiographic method was used to analyze the phases of the cardiac cycle in 20 macaques and 12 baboons. The duration of the principal phases of cardiac contraction was determined and the degree of their correlation with the duration of the cardiac cycle calculated.

The data obtained by phase analysis of cardiac activity of monkeys are few in number. Information on this subject [2, 3] is limited to the duration of mechanical systole and diastole.

The phase structure of the cardiac cycle was investigated in 20 macaques (Macacus rhesus and 12 baboons (Papio hamadryas). Synchronized recordings were obtained of the ECG, the apical phonocardiogram (PCG) in the auscultative range, and the sphygmogram (SPG) of the left axillary artery. The structure of the cardiac cycle was analyzed by the usual method [1].

The first sound of the PCG in M. rhesus usually consists of 3 components. The first component consists of 1 or 2 waves of low amplitude, and this is followed by 2-5 high-frequency waves with spindle-shaped changes in amplitude (2nd component), after which 1 or 2 low-voltage waves (the 3rd component) are recorded. The duration of the first sound varied from 0.04 to 0.06 sec (0.053 ± 0.001 sec) depending on the heart rate. The second sound consists of 2 components: the first component consists of 1 or 2 high-frequency and high-amplitude waves, and second component of 1 or 2 waves of lower amplitude. Depending on the duration of the cardiac cycle, the second sound varied in duration from 0.015 to 0.03 sec (0.023 ± 0.001 sec). As a rule, the first sound in M. rhesus is longer in duration and higher in amplitude than the second sound. In P. hamadryas the high-frequency component of the second sound often did not differ in amplitude from the first sound.

It is very difficult to record the carotid arterial pulse in monkeys. However, as these observations showed, by recording the SPG of the left axillary artery both in M. rhesus and in P. hamadryas, it was possible to distinguish all the components of the pulse wave required for phase analysis.

Because of the great variability in the heart rate of monkeys, the phase structure of cardiac contraction was analyzed within 3 frequency ranges: 1) duration of the cardiac cycle 0.4-0.5 sec; 2) duration 0.3-0.39 sec; 3) duration 0.2-0.29 sec. Figures for the durations of the principal phases of the cardiac cycle are given in Table 1.

The differences in the duration of the individual phases in M. rhesus and P. hamadryas can be detected throughout the structure of the cardiac cycle. This is true above all of the periods of contraction and expulsion. Cardiac contraction in M. rhesus is characterized by a long period of increased tone which, including the structural components of this period (the phases of asynchronous and isometric contraction), is much shorter in P. hamadryas. The longer duration of total systole in M. rhesus is relative as the result of lengthening of the contraction period. The same conclusion applies also to mechanical systole. The duration of mechanical systole was particularly sharply reduced with an increase in heart rate in P. hamadryas. The intrasystolic index (ISI) of the baboons was not only higher than in the macaques, but it also had a well-marked tendency to increase with an increase in heart rate; but the dynamics of the changes in the index of

Institute of Experimental Pathology and Therapy, Academy of Medical Sciences of the USSR, Sukhumi.
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TABLE 1. Results of Phase Analysis and Combined Indices of Cardiac Activity of M. rhesus and P. hamadryas (M ± m)

Index	Macacus rhesus	Macacus rhesus	Papio hamadryas	Macacus rhesus	Papio hamadryas
Duration of cycle C (in sec)	0,4—0,5	0,3—0,39		0,2—0,29	
Phase of asynchronous contraction P	0,051±0,001	0,044±0,001	0,027±0,001	0,026±0,004	0,020±0,001
		<0,001		<0,02	
Phase of isometric contraction (iC) P	0,038±0,002	0,039±0,001	0,027±0,001	0,028±0,002	0,007±0,001
		<0,001		<0,001	
Period of contraction (T)	0,089±0,001	0,083±0,003	0,054±0,002	0,054±0,002	0,029±0,001
		<0,001		<0,001	
Period of expulsion (E) P	0,159±0,001	0,143±0,002	0,146±0,004	0,095±0,003	0,128±0,001
		>0,2		<0,001	
Mechanical systole (S_m) P	0,197±0,002	0,180±0,001	0,173±0,004	0,123±0,003	0,136±0,001
		>0,1		<0,001	
Electromechanical systole (S_0) P	0,248±0,002	0,225±0,002	0,199±0,004	0,148±0,002	0,156±0,001
		<0,001		<0,001	
Diastole (D) P	0,174±0,003	0,147±0,002	0,144±0,004	0,117±0,002	0,119±0,001
		>0,2		>0,2	
ISI $= \frac{E}{S_m}$ 100%	80,7±0,6	77,9±1,5	83,8±1,8	76,7±1,6	93,3±0,7
P		<0,01		<0,001	
IMT $= \frac{T}{S_0}$ 100%	35,7±0,4	37,0±1,2	27,2±1,2	36,4±0,8	18,7±0,6
P		<0,001		<0,001	
ETMV$=E-\frac{t}{c}$ (sec)	17,2—21,5	22,0—28,6	22,4—29,2	20,0—28,5	26,5—38,4

TABLE 2. Coefficients of Correlation of Cardiac Phases and Combined Indices of the Cardiodynamics in Macacus rhesus and Papio hamadryas

Index	C	0,993 $P<0,001$	0,999 $P<0,001$	0,982 $P<0,001$	0,995 $P<0,001$	0,004 $P<0,1$	1,145 $P<0,1$
T	0,652 $P<0,001$	T	0,885 $P<0,001$	0,926 $P<0,001$	0,829 $P<0,001$	—0,144 $P<0,1$	0,199 $P<0,1$
E	0,877 $P<0,001$	0,150 $P>0,1$	E $P<0,001$	0,981 $P<0,001$	0,838 $P<0,001$	0,219 $P>0,1$	—0,023 $P>0,1$
S_0	0,829 $P<0,001$	0,399 $P<0,02$	0,860 $P<0,001$	S_0	0,871 $P<0,001$	0,047 $P<0,1$	0,140 $P>0,1$
D	0,938 $P<0,001$	0,672 $P<0,001$	0,712 $P<0,001$	0,908 $P<0,001$	D	0,011 $P>0,1$	0,179 $P>0,1$
ISI	0,093 $P>0,1$	—0,803 $P<0,001$	0,326 $P<0,05$	0,102 $P>0,1$	0,225 $P>0,1$	ISI	—0,619 $P<0,001$
IMT	0,176 $P>0,1$	0,951 $P<0,001$	—0,606 $P<0,001$	0,219 $P>0,1$	0,437 $P<0,01$	—0,979 $P<0,001$	IMT

myocardial tone (IMT) was opposite in character. The expulsion time of the minute blood volume (ETMV) also showed definite changes.

A high degree of correlation was found between the duration of the phases of the cardiac cycle (Table 2). No significant correlation was found between ISI and IMT on the one hand, and the duration of the phases of the cardiac cycle in M. rhesus on the other. Corresponding to the more marked changes revealed by phase analysis of the cardiac cycle in P. hamadryas, however, significant correlation was found between the phases of the cycle and the combined indices in this species.

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